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SOUTHERN FOREST COMMUNITIES

Community Description

Wisconsin's southern forest communities cover an area of about 16.5 million acres. They occur south and west of the climatic Tension Zone described by Curtis (1959) (Figure 1). The Tension Zone is the approximate area where vegetative communities change from the prairie, savanna, oak, and mixed hardwood forests of the south to the mixed deciduous-coniferous forests of the north. While the landscape in northern Wisconsin was largely forested prior to EuroAmerican settlement, the southern forests were interspersed with extensive prairie and savanna communities. Although a number of species range across both the northern and southern forests, there are floristic elements specific to each - boreal elements are found in the north and prairie elements in the south. Also, species abundances may differ - oaks are less common in the north - and species may occur in different assemblages. Historically, southern Wisconsin's communities included, in order of relative abundance, broad-leaved deciduous forest, oak savanna, conifer forest, prairie, and open wetland. Estimates of the extent of these communities vary depending on classification scheme and mapping methods (Curtis 1959, Finley 1976, Schulte *et al*. 2002).

Figure 1. Approximate location of the Tension Zone in Wisconsin (WDNR 1995, modified from Curtis (1959)).

Southern Wisconsin's fertile soils and milder climate made it suitable for many agricultural uses, which led to dramatic changes in the composition and extent of native vegetation. The fertile prairies, savannas, and forests were quickly cleared and converted to cropland or pasture by EuroAmerican immigrants during the 19th century. The greatest loss of forest occurred in the gentler terrain of the glaciated southeastern and south central portions of the state. In the more rugged Driftless Area of southwestern Wisconsin (sometimes referenced as the "Paleozoic Plateau" because this region was likely glaciated at more than 790,000 years ago), the steeper side slopes have generally remained forested, though the broader ridgetops and flat valley bottoms were converted to farmland wherever possible. The slope forests were often used by local landowners as sources of lumber and firewood, and many of them were also pastured. The infertile, coarse-textured soils and extensive wetlands of central Wisconsin made that region less suitable for agriculture than other areas in the south. Extensive forests occur there today, in part because of fire suppression that has allowed the pine barrens and oak savanna to succeed to oak and pine forests.

Current Vegetation

This section describes the current range of forest types in southern Wisconsin, and their associated shrub and herbaceous vegetation. There are a number of different ways to classify forest types. Data from the Forest Inventory and Analysis (FIA) program of the USDA-Forest Service were used to describe the forest overstory (Schmidt 1997). The FIA program classifies forest vegetation into 'forest type groups' made up of major tree species or groups of species that commonly occur together.

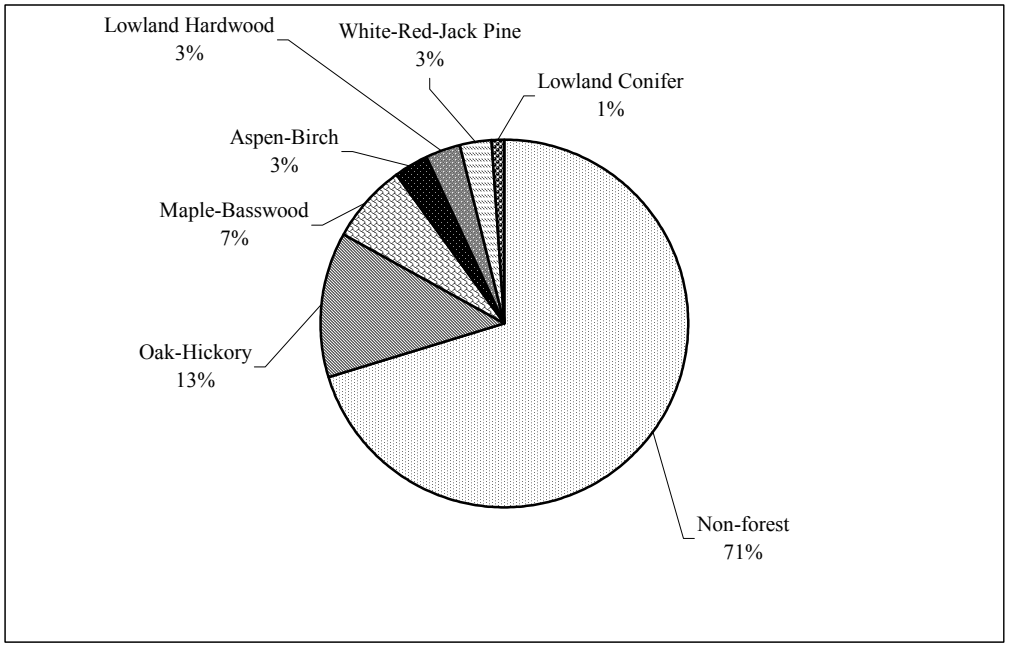
FIA methodology is more statistically valid over large areas than are other measures of forest composition. FIA data were analyzed by WDNR using the Tension Zone as the boundary between northern and southern Wisconsin.

Forest understory is not well-characterized by FIA, so we have used additional sources to describe these vegetative components, including Curtis (1959), Kotar and Burger (1996), and Bureau of Endangered Resources (BER) statewide inventory files. Plant nomenclature follows Voss (1972, 1985, 1996) and Mickel (1979).

Curtis (1959) divided Wisconsin's southern forests along a soil moisture gradient into several basic types characterized by a generalized overstory composition. The generalized groups include: wet, wet-mesic, mesic, dry-mesic, and dry forests. Some of the broad Curtis types have been further refined by the Natural Heritage Inventory program and are known as Natural Communities (WDNR, Bureau of Endangered Resources). The Natural Community classifications incorporate findings from recently completed vegetation studies, and describe rare or localized community types not mentioned by Curtis. These groups provide a better tool for identifying community level conservation priorities, and serve current needs for information exchange across administrative boundaries.

FIA analyses show that in 1996 there were approximately 4.8 million acres (31%) in southern Wisconsin classified as timberland. Northern Wisconsin, by comparison, has about 10.9 million acres of timberland (58%). The southern forest is characterized by broadleaf deciduous tree species and has a lesser proportion of conifers. About 32 native tree species can be found in the southern forest. The presence of each species will vary depending on environmental characteristics and past disturbance. Percentages of various forest types are shown in Figure 2.

Figure 2. Land area south of the Tension Zone in Wisconsin, showing proportions of forested and non-forested lands, and forest type groups as inventoried in 1996 by FIA (Schmidt 1997).



Oak-hickory is the most common forest type group in the southern forest, occupying about 13% (2.1 million acres) of the land area and 44% of the area classified as timberland. This community includes red oak (*Quercus rubra*), white oak (*Q. alba*), black oak (*Q. velutina*), bur oak (*Q. macrocarpa*) and shagbark hickory (*Carya ovata*), often with components of red maple (*Acer rubrum*), aspen (*Populus* spp.), basswood (*Tilia americana*), paper birch (*Betula papyrifera*), white pine (*Pinus strobus*), or black cherry (*Prunus serotina*). Oaks dominate the forest composition in a majority of the oak-hickory stands, although red and sugar maple (*Acer saccharum*), red elm (*Ulmus rubra*), white ash (*Fraxinus americana*), and black cherry are increasing in abundance due changes in the frequency of fire, their greater tolerance of shade, and ability to quickly sprout back after logging disturbances. These species also tend to exhibit rapid growth rates and are less palatable to white-tailed deer and cattle.

Information on understory vegetation was derived from Curtis (1959), Kotar and Burger (1996), and from BER files. The oak-hickory group is similar to Curtis' (1959) southern dry and southern dry-mesic forest communities. Characteristic

understory species on dry and dry-mesic sites include shrubs such as hazelnut (*Corylus americana*) and gray dogwood (*Cornus racemosa*), the low, twining hog-peanut (*Amphicarpaea bracteata*), and herbs such as false Solomon's seal (*Smilacina racemosa*), lopseed (*Phryma leptostachya*), tick-trefoils (especially *Desmodium glutinosum* and *D. nudiflorum*), and enchanter's nightshade (*Circaea lutetiana*). Lady fern (*Athyrium filix-femina*) and interrupted fern (*Osmunda claytoniana*) are often present in dry-mesic oak forests. The prevalence of woody shrubs, as well as the saplings of shade tolerant but fire-sensitive trees, are likely due in part to the exclusion of fire from the southern landscape. Lack of fire has also resulted in changes to the herbaceous component of the oak forests. Lightdemanding plants, mostly summer- and fall-blooming species, were very prevalent in southern oak woods 50 or more years ago (Curtis 1959). Now they have become far less common, and are often restricted to edges, trails, and major canopy gaps. These species include many grasses, sedges, legumes, figworts, mints, parsleys, and a wide variety of composites, including asters, goldenrods, sunflowers, and others.

The second most common forest type group in the south is maple-basswood. It occupies about 7% (1.2 million acres) of the land area and 25% of timberland. Among the canopy dominants are sugar maple, basswood, white ash, and near Lake Michigan in eastern Wisconsin, American beech (*Fagus grandifolia*). Important associates include red oak, red maple, red elm, bitternut hickory (*Carya cordiformis*), black walnut (*Juglans nigra*), and others (Curtis 1959).

The maple-basswood group most closely matches Curtis' southern mesic forest, a forest type characterized by a dense canopy, high internal humidity, and adequate moisture throughout the growing season. The best-known understory plants of the mesic hardwood forests are collectively termed the *spring ephemerals*. The true ephemerals complete their life cycle over a few short weeks in the spring, emerging shortly after the departure of frost from the soil, and often concluding before the trees are fully leafed out. Trout lilies (*Erythronium albidum* and *E. americanum*), Dutchman's breeches (*Dicentra cucullaria*), spring beauty (*Claytonia virginica*), toothwort (*Dentaria laciniata*), and false rue anemone (*Isopyrum biternatum*) are among the characteristic spring wildflowers of mesic hardwood forests. Other herbs representative of this type include wild ginger (*Asarum canadense*), bishop's cap (*Mitella diphylla*), mayapple (*Podophyllum peltatum*), blue cohosh (*Caulophyllum thalictroides*), trilliums (*Trillium spp.*), and violets (*Viola spp.*)

Lowland hardwood forests (collectively referred to as the Elm-Ash-Cottonwood forest type group in FIA publications), cover 3% (550,000 acres) of the land area and 11% of timberland. American elm (*Ulmus americana*) was formerly an important member of the lowland hardwood forest, but Dutch elm disease has devastated its populations throughout the species' range. Young elm is still relatively common in lowland forests, but seldom reaches the canopy before succumbing to Dutch elm disease. Important canopy species include silver maple (*Acer saccharinum*), red maple, green ash (*Fraxinus pennsylvanica var. subintegerrima*), swamp white oak (*Quercus bicolor*), river birch (*Betula nigra*), cottonwood (*Populus deltoides*), hackberry (*Celtis occidentalis*), and black willow (*Salix nigra*). Several lowland trees with ranges centered in the southern U.S., such as sycamore (*Platanus occidentalis*), honey locust (*Gleditsia triancanthos*), and Kentucky coffee tree (*Gymnocladus dioicus*), can be found in bottomlands along the major river systems in extreme southern Wisconsin.

Though all lowland hardwood forests are subject to periodic episodes of high water, becoming either saturated or flooded, there are distinct functional differences between forests on river floodplains and those in isolated lowland basins (Dunn 1987). Floodplain forests are subject to scouring effects (water, ice, and debris), sediment deposition, and periods of saturation or inundation interspersed with very dry conditions. Vegetative composition, including successional patterns, can vary depending on the timing and severity of flooding. Flood regimes have been significantly affected by dam construction, wetland drainage, channelization, road construction, and urban development. Other factors that have affected this forest type include logging, grazing, ditching, and colonization by invasive plants. Lowland hardwood forests in closed depressions may be subject to prolonged periods of saturation or inundation by standing, rather than moving, water – especially in the spring or after major precipitation events. These hydrologic differences lead to understory composition and growth rates that are distinctly different from that of floodplains.

Common understory plants of the lowland hardwood forests often occur in a patchy distribution. They include wood nettle (*Laportea canadensis*), sedges (*Carex spp.*), grasses, touch-me-not (*Impatiens biflora*), cardinal flower (*Lobelia cardinalis*), green dragon (*Arisaema dracontium*), green-headed coneflower (*Rudbeckia laciniata*), and buttonbush (*Cephalanthus occidentalis*). Vines are often prominent in floodplain forests, particularly wild grape (*Vitis riparia*), woodbine (*Parthenocissus vitacea*), poison ivy (*Rhus radicans*), moonseed (*Menispermum canadense*), and wild cucumber (*Echinocystis lobata*) (Curtis 1959).

The most extensive acreage of pine-dominated forest in southern Wisconsin is in the sandy regions of the Central Sands and Central Sand Hills Ecological Landscapes. Forests of red pine (*Pinus resinosa*), white pine (*Pinus strobus*) and/or jack pine (*Pinus banksiana*) occur on 3% (430,000 acres) of the land area and comprise 4% of timberland. The "Current Land Cover" maps in the Ecological Landscape chapters show the relative prevalence of conifers in these landscapes. Monotypic pine

plantations make up a substantial portion of this forest group today. Red pine forests occupy about 210,000 acres of southern Wisconsin as estimated from FIA data, of which about 96% are plantations. Much of southern Wisconsin is outside the natural range for red pine. White pine seedlings are becoming abundant in forests of the Central Sands and Central Sand Hills and this species is likely to increase in dominance over time. Natural pine forests in southern Wisconsin may bear strong similarities to pine forests of the north, with a ground flora that includes blueberries (*Vaccinium angustifolium* and *V. myrtilloides*), wintergreen (*Gaultheria procumbens*), bracken fern (*Pteridium aquilinum*) and pipsissewa (*Chimaphila umbellata*). They differ from northern pine forests in that they often include species whose ranges are centered further south, such as prairie or savanna species. Patches of pine forest in the Driftless Area are often small and isolated, sometimes lack characteristic "northern" understory plants, and are often found within a landscape matrix that contains more agricultural and residential land than is typical of the north.

In southwestern Wisconsin's Driftless Area, rocky bluffs may support small, xeric stands of white, red, or jack pine. White pine is more widely distributed than the other conifers, occurring as a component of dry-mesic (and sometimes dry) forests in a number of locations. It is an important canopy species in forests on older glacial materials deposited prior to the Wisconsin glaciation, including areas in Dunn, Pierce, and St. Croix counties.

Aspen and paper birch (*Betula papyrifera*) forest types occupy 3% (444,000 acres) of the land area and 9% of timberland. Stands often occur on grazed, high-graded, or otherwise disturbed slopes in the Driftless Area, and on a variety of sites at scattered locations throughout the Central Sands and Central Sand Hills Ecological Landscapes. Paper birch frequently occurs on Driftless Area bluffs that formerly supported prairie or oak savanna vegetation, and it may become increasingly dominant in the absence of fire or under certain grazing regimes. Paper birch and aspen can also become abundant on slopes that are heavily logged for either commercial purposes or to increase areas of open pasture. The understory vegetation of such stands has not been studied in detail, but anecdotal evidence and observations suggest that on disturbed sites such forests often support weedy invasives, non-native graminoid plants, thorny or spiny shrubs, and herbs that thrive in a variety of forest habitats.

Lowland conifer forests occupy less than 1% (60,000 acres) of the land area and 1% of timberland. The dominant trees are tamarack (*Larix laricina*), northern white-cedar (*Thuja occidentalis*), and in a few areas, black spruce (*Picea mariana*). Typical sites include damp basins in the glaciated landscapes of southeastern and central Wisconsin, the vast, poorly-drained bed of extinct Glacial Lake Wisconsin in the Central Sands Ecological Landscape, and, rarely, as isolated remnants in Driftless Area valleys. These forest communities, widespread and characteristic north of the Tension Zone, support a complement of plants and animals that are uncommon and highly localized in the south. Concerns have been raised in recent years over the ability of these northern outliers to persist when they are subject to damage by excessive browse pressure, altered hydrologic regimes, and the spread of invasive plants. Tamarack forests are affected by periodic infestations of the larch sawfly, and, possibly, the exclusion of wildfire. Climate change is also a factor that could potentially have negative impacts on lowland conifer forests in southern Wisconsin.

Several forest types of minor extent are not described separately by FIA. At a few locations in the Driftless Area, cool, moist microsites support small stands composed of species characteristic of the northern mesic forest, including eastern hemlock (*Tsuga canadensis*) and yellow birch (*Betula alleghaniensis*). The typically northern understory plants such as mountain maple (*Acer spicatum*), Canada yew (*Taxus canadensis*), bluebead lily (*Clintonia borealis*), and others may be present. Geographically disjunct from the main range of this forest type, these Driftless Area "relicts" often support species that are regionally rare. "Periglacial relicts" - species that for one reason or another were unable to retreat north as the climate warmed following the last glacial episode - occur in some of these stands. The "relict" species, including a number of land snails and several plants, were able to persist only in locations that are perpetually moist and cold, conditions that are extremely rare and localized in southern Wisconsin today.

Another minor type is red cedar (*Juniperus virginiana*) forest, which developed on sites subjected to grazing and the loss of periodic fire disturbance. Also, some clay ravines along Lake Michigan support stands of hemlock, white cedar, and white pine. A few sites support boreal forest remnants dominated by spruce, fir, and other conifers (e.g., locations in Pierce Co.). Plantations of black walnut, Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*), American chestnut (*Castanea dentata*), and other species can also be found in southern Wisconsin.

Forested parks and reserves in urban areas are an important component of southern Wisconsin's cities, both as a source of open space for recreation and for wildlife habitat. A variety of wildlife species are found in these areas, but the near proximity of humans usually makes urban locations unsuitable for long-term habitation by less-common species. Some rarer bird species may use urban areas as stopovers during migration periods, but are unlikely to remain there for more than a few days. Forested parks and reserves, as well as trees planted along streets and in yards of residences or commercial lots provide

many ecosystem services in the cities. They keep the area cooler in summer, reducing energy demands for air conditioning. Conifers in particular provide wind protection that reduces heating needs in winter. Urban trees offer shade and some degree of protection from ultraviolet radiation. They intercept precipitation, allowing its absorption into the soil, and reducing erosion. Trees also mitigate the effects of some pollutants by utilizing carbon and nitrogen. They are aesthetically pleasing and often are highly valued by urban residents. The cultivation of both native and non-native trees gives urban forests a great variety of species. Controversy exists over the choice of tree species to plant. Urban homeowners tend to favor fast-growing tree species that are easy to care for, but some non-native trees such as Norway maple have become a problem when they spread from planted areas. Many of our native tree species have difficulty surviving in urban areas because of pollution, soil compaction, and lack of soil moisture.

Non-forested lands occupy about 71% (11.8 million acres) of southern Wisconsin. They include agricultural lands, areas developed for residential, commercial, industrial and transportation uses, savannas, barrens, prairies, grasslands (including hay, pasturelands, and Conservation Reserve Program fields), and various types of non-forested wetlands. Oak savannas, barrens, grasslands, and wetlands are described in separate community chapters of this handbook.

Historic Vegetation

Before EuroAmerican settlement, the southern forests were much different than today. The early explorers, missionaries, and settlers described open, "park-like" forests dominated by widely-spaced oaks with a paucity of shrubs or saplings. The oak forests and savannas were interspersed with prairies and wetlands, and some areas of maple-dominated forest. The first Public Land Survey (PLS) was conducted by the General Land Office in Wisconsin between 1832 and 1866. As part of the survey, tree species and diameters were recorded along township and section lines; these data now provide a great deal of the available information about Wisconsin's historic vegetation.

Classification and description of the historic forests of southern Wisconsin is complicated by data gaps, ambiguities in the information, and the wide variety of ecosystems that exist in the area. Southern Wisconsin contains both glaciated and unglaciated areas, and a wide range of soil, hydrologic, and topographic conditions. There are very few tracts of original vegetation remaining to serve as reference areas for study and description. Formerly widespread and abundant fire-dependent communities such as the tallgrass prairies and oak savannas have been almost completely obliterated, with less than 1% remaining of the acreage estimated at the time of the PLS.

Curtis (1959) described the historic vegetation of Wisconsin and created a map based on interpretation of PLS maps and data. Finley (1976) prepared a more detailed map, also based on PLS information, classifying the state into a number of distinct vegetation types. Finley's map is shown in the Statewide Maps section of this Handbook as "Finley's Presettlement Vegetation." More recently, PLS information has been digitized and is in the process of being reanalyzed (Schulte *et al*. 2002). Ultimately, the reanalysis will provide more accurate and detailed information about the forests of the mid-1800s, but is not yet available in a form that permits characterization of broad forest types. Maps of the digitized PLS data are included in each Ecological Landscape chapter of this Handbook as "Forest Cover of the mid-1800s."

Finley's (1976) forest type categories were analyzed by WDNR to describe components of Wisconsin's historic southern forests. Finley's forest types were used because they were considered the best available information, and because GIS layers existed for determining extent of forest types. Curtis is thought to have used coarser methods for estimating extent, and Schulte *et al*. (2002) data are not yet classified into vegetation types.

Historic Forest Types

White oak-black oak-bur oak forest types occupied 28% (about 4.7 million acres) of southern Wisconsin, mainly in the Western Coulees and Ridges, Central Sand Hills, and Southwest Savanna Ecological Landscapes. The major disturbance regime was fire, which created a range of conditions from closed forests to open, park-like forests, to savannas. Grazing and browsing by native ungulates, including elk and white-tailed deer, likely influenced forest development and species composition. Where fire was not frequent, mesic forests of sugar maple-basswood prevailed, provided that substrate and moisture conditions were appropriate. Oak woodlands are an additional structural condition that has been proposed as intermediate between closed forests and savannas, but no extant examples are available to provide the basis for a detailed description. Oak woodland is thought to have had a high canopy closure and an open understory resulting from frequent ground fires of relatively low intensity.

Sugar maple-basswood with red oak, white oak, or black oak as major associates occupied about 14% (2.4 million acres) of southern Wisconsin. This forest type occurred mainly in a triangular wedge within the Western Coulees and Ridges, in a fire shadow created by the Kickapoo River Valley, and in the Southeast Glacial Plains Ecological Landscapes. The major natural disturbance in the mesic forests was windthrow, which created small forest gaps at relatively frequent intervals. Large, extensive wind disturbances were probably uncommon, since they were seldom referenced in the PLS notes (Schulte and Mladenoff, in review). However, some larger gaps created by wind or fire would have been necessary to initiate development of the oak component in these forests. Grazing by native ungulates may also have played a role in forest succession.

American beech - sugar maple - basswood with red, white or black oak as major associates occupied about 0.4% (60 thousand acres) of southern Wisconsin. This forest type occurred in a long narrow north-south belt along Lake Michigan, on both sides of the Tension Zone. Most of the area was within the Central Lake Michigan Coastal Ecological Landscape, where climatic moderation due to the lake causes the Tension Zone to shift southward. In this unique climatic zone, hemlock, white pine, and white cedar occurred as far south as Milwaukee County. Wind was the dominant disturbance, creating small forest gaps in which the shade-tolerant trees regenerated. Occasional larger gaps or fires would have initiated oak development. Lake effect snow and ice storms would have also played a role in forest development.

White pine - Red pine forest occupied about 2% (335,000 acres) and *Jack pine - scrub oak - barrens* about another 5% (830,000 acres). These pine-dominated areas were mostly located in the Central Sands and Central Sand Hills Ecological Landscapes.

Other important historic types described by Finley included the lowland hardwood forests, found in poorly drained depressions in glaciated areas and within the floodplains of the major rivers. Lowland hardwoods occupied about 1% (220,000 acres) of the area. Floodplain forests were particularly well developed within the Driftless Area along the Mississippi, Wisconsin, Chippewa, and Black Rivers. Significant stands were also present in eastern Wisconsin along the lower Wolf and Milwaukee rivers, and along the Sugar River in south central Wisconsin. Important trees of the lowland forest included American elm, silver maple, green ash, river birch, swamp white oak, hackberry, cottonwood, and black willow. Swamp conifers, including white cedar, black spruce, and tamarack, occupied about 4% (650,000 acres) of southern Wisconsin. The aspen, paper birch, and pine forest type occupied less than 1% (80,000 acres).

Historic Non-Forest Vegetation

Oak openings – bur oak-white oak-black oak occupied 20% (about 3.4 million acres) of the area in the Southwest Savanna, Southeast Glacial Plains, and Western Coulees and Ridges Ecological Landscapes. This savanna community (further discussed in the *Oak Savanna* chapter in this section of the handbook) occurred as a transition between oak forest and prairie. The extent of this community type was likely quite dynamic, depending on the frequency, severity, and seasonality of wildfire. Fire was the major disturbance regime responsible for both creating and maintaining the savannas.

Other non-forest vegetation. Marsh and sedge meadow covered about 7% (1.2 million acres) of the land area. Wet prairie occupied about 10% (1.7 million acres), and approximately 4% (670,000 acres) was lowland shrub vegetation.

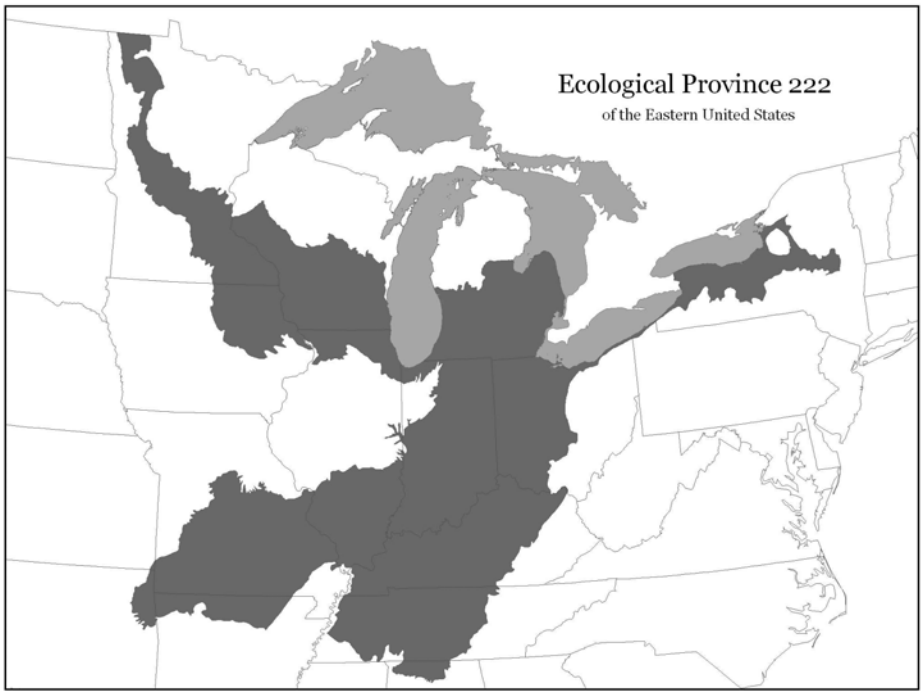
Global/Regional Context

Ecoregions with climate and soils similar to those of southern Wisconsin are not common worldwide. They can be found in Europe in parts of Poland and Germany, and in an area of far-eastern Asia that includes portions of the Koreas, China, and Russia (Bailey 1996). The vegetative biome is within the temperate broadleaf forest, but in Wisconsin and similar ecoregions, composition is limited to species that can tolerate relatively hot summers with occasional periods of drought.

Oaks are common tree species of the ecoregion, and one of the most important types of woody plants in the Northern Hemisphere. They have been a major source of fuel, animal feed, and lumber. Acorns were historically an important food for indigenous people in North America, Europe, and Asia.

Southern Wisconsin forests lie within the ecoregion known as Province 222, the Eastern Broadleaf Forest, as classified in the National Hierarchical Framework of Ecological Units (NHFEU) (Keys *et al*. 1995) (Figure 3). Province boundaries are based on differences in continental climate as reflected in the vegetation of biomes. Province 222 is characterized by a hot continental climate, with hot summers and cool winters, supporting natural vegetation dominated by broadleaf deciduous forest. In Wisconsin, climatic differences between Provinces result in the vegetative changes evidenced along the Tension Zone.

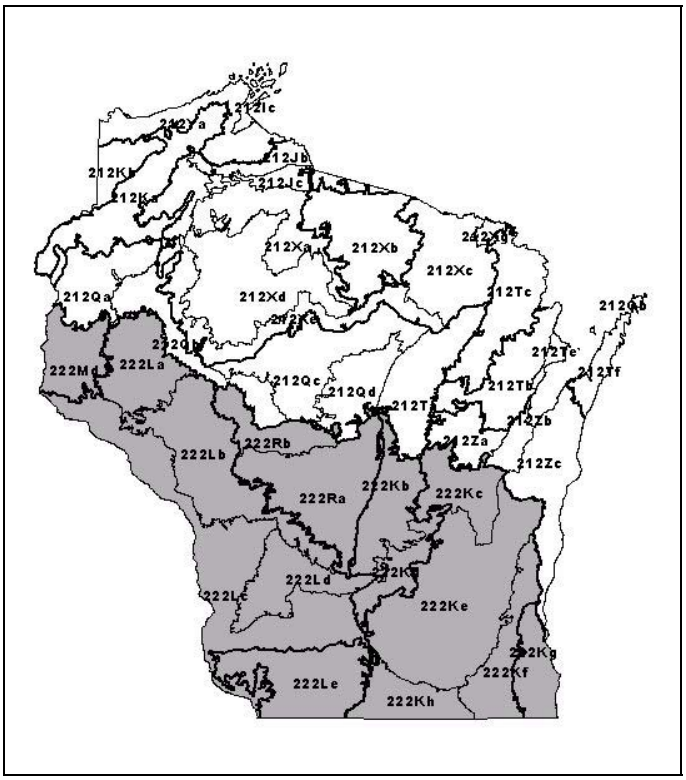
Figure 3. The Eastern Broadleaf Forest Province (222) is shown shaded below. Province 222 includes parts of Minnesota, much of the Lower Peninsula of Michigan, and parts of New York, Ohio, Indiana, Kentucky, Tennessee, Illinois and Missouri. In Wisconsin, the northern boundary of Province 222 lies along the Tension Zone.



Within southern Wisconsin, finer scaled ecological units are delineated at the Section and Subsection levels of the NHFEU (Figure 4). Section-level ecological units include: 1) the Southwestern Great Lakes Morainal Section, 2) the North Central U.S. Driftless and Escarpment Section, 3) the Minnesota and North Eastern Iowa Morainal Section, and 4) the Wisconsin Central Sands Section. Sections are based on climatic differences within a Province, and also on broad-scale geomorphic features. In southern Wisconsin, most Section boundaries coincide with the margins of major glacial lobes that existed during the Wisconsin glaciation. There are 15 Subsections nested within the four Sections. In glaciated areas, Subsections are mapped based on associated groups of glacial landforms, including morainal systems or outwash systems. In unglaciated areas, Subsections are based on similar geomorphic environments, such as bedrock characteristics that lead to certain patterns of erosion and valley formation. All the Subsections have distinguishing soil and vegetation attributes, and different

combinations of forest communities. The Ecological Landscapes used in this Handbook are based substantially on Subsections of the NHFEU.

Figure 4. Section and Subsection levels of the ecological land classification system (NHFEU) in Wisconsin. Province 222, the Eastern Broadleaf Forest, is shaded. Its northern boundary approximates the Tension Zone in Wisconsin. Ecological Landscape boundaries are shown in heavier lines.



Assessment of Conditions Over Time

Current conditions in the southern forest are a result of interactions between the physical and biological environment, and the history of land use by humans. The history of ecosystem development is significant in characterizing today's forests.

Past Conditions

Glaciation has been a major influence on ecosystem development in Wisconsin. Through the ages, most of the state was covered repeatedly by advances of major continental ice sheets. A number of glacial events occurred during the Pleistocene epoch of the past 1.7 million years. The most recent was the Wisconsin glacial stage; glaciers reached their maximum southerly extent at about 25,000 years ago, and slowly retreated, readvanced in places, and finally melted back into Upper Michigan at about 9,000 years ago. In the southeastern portion of Wisconsin, the glacier left behind a rolling plain with typical glacial features, including rugged end and recessional moraines, extensive drumlin fields, eskers, kames, ice-contact hills, outwash plains, and lake plains. Forest ecosystem development was constrained by characteristics of these glacial features; for example, jack pine forests were able to survive on droughty sands in outwash and lake plains, while maple forests required the nutrient-rich soils and mesic conditions of morainal landforms. Land use by indigenous and modern-day humans has also been limited by the landscape's physical characteristics, directly traceable to the Wisconsin glaciation.

Following glaciation, before vegetation became established, windblown silt was deposited over much of Wisconsin. This material, known as loess, was brought from the Mississippi River Valley by prevailing westerly winds. Areas that received a thick deposit of loess tend to be more mesic, because of the moisture-holding capacity of silt. Loess is not deposited evenly over Wisconsin; it drifted and piled up in some places, and was later eroded away in others.

The southwestern portion of the state was not glaciated during the Wisconsin glaciation, and is known as the "Driftless Area." Although it was not covered by the Wisconsin glaciation, it is believed to have been glaciated at more than 790,000 years ago (Clayton *et al*. 1991). The landscape is characterized by level or rolling ridges capped with fertile loess soils, deep steep-sided valleys, and frequent outcroppings of Paleozoic sedimentary rock, sandstones and dolomites.

Glacial Lake Wisconsin, a large lake that existed in central Wisconsin between about 19,000 and 14,000 years ago, was formed when westward moving ice of the Green Bay lobe dammed the Wisconsin River at Devil's Lake in the Baraboo Hills. Water from the melting ice formed a lake that covered 1,825 square miles in central Wisconsin. About 14,000 years ago, the ice dam at the east end of the Baraboo Hills melted sufficiently for the lake to break through. The deep gorge and sandstone cliffs of the Dells of the Wisconsin River were at least partially formed by this final, catastrophic drainage of the glacial lake (Clayton and Attig 1989, LaBerge 1994). The lake left extensive sand deposits, providing the appropriate physical environment for the development of pine and mixed oak-pine forests, barrens, and peatlands.

Geographic origins of Wisconsin's southern forests are varied. After glaciation, species moved northward from several refugia, including the Appalachian (mesic maple-basswood associations), Ozarkian (dry oak-hickory associations), and Mississippi Embayment (lowland hardwood species). Boreal species mostly occurred in a zone near the ice sheet, and followed its retreat northward. Examination of fossil pollens in peat bogs led several investigators to postulate that hickory, basswood, and maples, among others, had found refugia in the Driftless Area during glacial advances and moved eastward following the retreat of the ice fronts (Braun 1950, Sears 1942).

Fire was a significant influence on composition, distribution, and dynamics of pre-EuroAmerican settlement forests. Based on climate, soil moisture, and nutrient levels, many areas in southern Wisconsin are capable of supporting mesic hardwood forests dominated by sugar maple and basswood. The mosaic of oak-dominated forest, savanna, and prairie that covered most southern landscapes into the 1800s was largely the result of fire regimes that existed for 5,000-6,000 years (Bray 1960). Fire-dependent communities such as prairie and oak savanna were generally found west and south of fire barriers created by marshes, rivers, lake complexes, and rugged hills. In these areas, prevailing winds could carry fire unimpeded (Dorney 1981). Mesic forests of maple-basswood or maple-beech tended to persist on sites north and east of fire barriers.

There is controversy about the land use practices of Native Americans prior to EuroAmerican contact. By the mid-1600's, when Jesuit missionaries wrote the first accounts of tribal life in Wisconsin, the culture had already been changed by the influx of Native American refugees from the east. These tribes were fleeing the "Iroquois Wars", intertribal warfare caused by territory disputes related to the fur trade (Trigger 1978). Because of the lack of early records, it is not possible to say conclusively how Native Americans affected the environment of Wisconsin prior to the 1650s, but some general characterizations are possible based on archaeological records.

In southern Wisconsin, sometime between 300 BC and 400 AD, peoples of the Middle Woodland culture began to build burial mounds, establish permanent villages, and practice early forms of agriculture. Many archaeologists suggest that horticulture or gardening rather than farming was practiced during this period (Ritzenthaler 1985). Hunting, fishing, and collecting plant seeds were important during the Middle Woodland period. Archaeological sites representing this period are typically found in riverine settings with relatively large site sizes and deep village deposits. Prior to the emergence of the Woodland cultures, Native Americans in Wisconsin had subsisted almost entirely by hunting, fishing, and gathering.

The Late Woodland period (400 AD to 1100-1200 AD) saw an increasing reliance on agriculture, larger populations, a more settled village life, and the introduction of bow and arrow. Meanwhile, in northern Wisconsin, fishing, hunting, and gathering were still predominant. In the transitional zone between northern and southern forests, groups practiced horticulture to varying degrees, but could not rely on it for all of their subsistence needs (Ritzenthaler 1985).

Wisconsin's "effigy" mounds in the form of animals were constructed by Late Woodland peoples between approximately 650 AD to 1100-1200 AD. This group declined rapidly and had virtually disappeared by about 1500 AD. It is unclear whether this was due to crop failure, infectious diseases (particularly those that may have spread from early contact with Europeans, such as smallpox, measles, cholera, and diphtheria), warfare, political upheaval, a combination of these factors, or some other cause. Following the disappearance of these agriculture-based societies, Wisconsin was populated by the Winnebago (now known as the Ho-Chunk, whom some historians believe to be descendants of the mound-builders) in the south, the Menominee in the northeast, the Ojibwa in parts of the north, and the Santee Dakota (a Siouxian tribe) in the west.

Cultures of the Mississippian Phase occupied much of south-central and southeastern Wisconsin between about 1000 and 1500 AD. This group was noted for the large development at Aztalan on the Crawfish River in what is now Jefferson County, and for their cultivation of maize, beans, and squash. Inhabitants also used many wild plants like hickory nuts, acorns, and a

variety of berries. They ate large quantities of white-tailed deer meat as well as lesser amounts of elk, raccoon, beaver, muskrat, and fox. Fish were another important component of their diet, including catfish, bass, suckers, buffalo fish, pike, drum, and freshwater mussels. They also consumed turtles and birds, including Passenger Pigeons, ducks, turkeys, geese, and swans (Ritzenthaler 1985).

Peoples living near the upper Mississippi River during this time are known as Oneota. Their permanent villages were located primarily in lake and riverine areas, often adjacent to associated wetlands. There is evidence of maize agriculture, as well as cultivation of beans and squash (Mason 1988), but like the Late Woodland period, hunting, fishing, and gathering were more important to subsistence of this group (Ritzenthaler 1985). A number of Oneota groups likely became the present day Winnebago (i.e. Ho-Chunk) and Ioway tribes (Ritzenthaler 1985, Boatman 1998).

The Ho-Chunk culture is representative of Native American activities in southern Wisconsin during the period just prior to European influence (1500 to 1650). They were the primary residents of the east-central and southwestern parts of the state during this time (Boatman 1998). Estimates of Ho-Chunk population size prior to EuroAmerican contact range from 8,000 to around 20,000.

The Ho-Chunk lived chiefly in oak forests and savannas that were somewhat protected from fire by landscape barriers. Villages were often sited along rivers, where dugout canoes were used for transportation. Villages varied in size; some covered hundreds of acres, but many were semi-permanent and much smaller. Bands engaged in seasonal activities, dispersing for the fall hunt, and reconvening in small winter habitations that were generally located in heavily wooded stream valleys. Hunting and fishing were the primary springtime activities, followed by a return to the summer villages to cultivate crops, including corn, beans, squash, melons, and tobacco. Cultivated fields were usually placed in floodplains, where soils were fertile and relatively easy to till (The Wisconsin Cartographers Guild 1998). Agriculture was probably not extensive throughout all of southern Wisconsin, though “hundreds of acres of corn, squash, beans, and melons” were noted by Europeans in the immediate vicinity of at least some larger villages (Hanson 1993). Wild rice grew abundantly in dense stands in the shallow slow-moving portions of many southern Wisconsin waterways, and was a staple of the diet, along with animal meat, nuts, and berries.

Though the historical literature contains few records about the use of fire by the Ho-Chunk prior to 1650, fire was undoubtedly used to drive game, expose enemies, maintain berry patches, and keep trails clear of undergrowth. Fire was also used in conjunction with tree girdling to clear land for agriculture, but it is unknown to what extent this occurred (Hanson 1993).

Drawings and records indicate that dogs were common in Native American villages. Dogs were domesticated in Asia and came to North America across the Bering land bridge along with the first humans (Leonard *et al*. 2002), so were likely present in the southern Wisconsin landscape for at least the past 11,000 years. Dogs were not used for hunting at this time, so impacts on native wildlife were likely minimal.

In the mid-1600s, several additional tribes moved into southern Wisconsin as a result of the Iroquois Wars. They displaced the Ho-Chunk, whose populations had been devastated by disease and warfare. Refugee tribes included the Potawatomi, Kickapoo, Sauk, Fox, and Mascouten. The Potawatomi eventually came to occupy southeast Wisconsin, while the Kickapoo, Sauk, Fox, and Mascouten dominated the southwest.

Jean Nicolet was the first European to arrive in Wisconsin, in 1634. The fur trade took hold in the 1650s, and French traders, soldiers, and Jesuit priests moved into the area, building trading posts, missions, and forts. Native Americans became dependent on trade goods, weapons, and ammunition obtained from the French traders. Pelts of many animals, especially beaver, were shipped from Wisconsin. After 1760, the fur trade became dominated by the British, and after the War of 1812, by Americans. The fur trade collapsed by 1850 due to a lack of fur and a decline in European demand.

The agricultural period began in southern Wisconsin in the 1830s, after treaties were signed with Native Americans. Lands were surveyed, and farmers began claiming the land and clearing forests and savannas. Early logging in the forests of southern Wisconsin has not been extensively documented. One description of logging in the Baraboo Hills area comes from Lange (1990), who notes that settlers cleared land for housing, cultivation and pasture. Although some wood was used as building material, fences, or fuel, most was burned in huge piles at celebrations called logging bees. Additional smaller uses included lime processing for fertilizer, plaster, or mortar; charcoal production for smelting ore; and specialized refining for bolts and hoops.

White pine logging began near the major rivers in the 1830s. Waterways were of prime importance for the transport of logs to populated areas such as Chicago and St. Louis before the railroad system became well-established in the 1870's. The main rivers used in southern Wisconsin were the Wisconsin, Chippewa, Black, Rock, Fox, and lower Wolf. Some rivers were impacted by logging, and became clogged with sediment and structurally altered by the wing and sluice dams that were built for log drives. Toward the mid 1800s, pine logging moved northward, as large numbers of European settlers entered Wisconsin and the pineries that existed in the Central Sands, the Baraboo area, and along the Black and Kickapoo Rivers were quickly exhausted.

In northern Wisconsin, the lasting EuroAmerican impacts were mainly on forest composition and structure, whereas in the south, settlement often meant outright elimination of forests and conversion of the land to agriculture. In addition, southern forests were frequently grazed by livestock after they were logged. Wildfires were suppressed in order to protect homes and other structures, and crops. Oak savannas were converted to farmland or succeeded to oak forests.

Recent Conditions

Although total acreage of the present day southern forest has increased by about 200,000 acres between 1983 and 1996(FIA), land use and ownership patterns have resulted in significant forest fragmentation throughout southern Wisconsin. Outright forest loss has been widespread in the areas suitable for agricultural and residential development. Another major change was the conversion of open and semi-open prairie and savanna landscapes, which succeeded to closed-canopy forest following the exclusion of periodic fire. In many areas, the canopy composition of the southern forest is now steadily shifting from oak dominance to shade tolerant mesic hardwoods, primarily due to the absence of the formerly widespread fire disturbances that maintained large acreages of oak forest. This situation is exacerbated by the selective removal of the commercially valuable oaks, still a common practice in southwestern Wisconsin.

Timber harvest levels in the southern forest increased overall from 1983 to 1996. Red and white oaks were the most harvested species. For the most part, growth exceeded removals, with some key exceptions. Northern red oak removals from growing stock (merchantable trees over 5" in diameter) far exceeded net growth for this category; 33 million cubic feet were removed annually, on average, while 15 million cubic feet were gained in net annual growth. These trends in oak removal, along with regeneration problems, point to a possibly serious issue of decline in the oak forests. An additional problem can arise when the maturing oaks are harvested, when some landowners and/or loggers choose to harvest only the trees of greatest commercial value, a practice called *high grading* (WDNR 2000). Stands that have been high graded usually have poor regeneration of the valuable oaks, and the residual trees are mostly other hardwoods of lower economic value.

Over the last 150 years there has been dramatic fragmentation of the southern forest. Due to increasing human population and associated development pressure, there are few remaining large blocks of forested land in the southern forest. The average size of private non-industrial forest land parcels declined from 36 to 30 acres between 1984 and 1997 in southern Wisconsin. By comparison, in northern Wisconsin parcel size declined slightly, from 44 to 43 acres, during the same time period (Roberts *et al*. 1986, Leatherberry 1997).

The length of time that a landowner retains ownership of forested land is a factor in parcelization. As land prices increase there is a greater chance the parcel will be subdivided at each succeeding sale. In 1997, landowner tenure in southern Wisconsin (19 years) was slightly less than in northern Wisconsin (20 years) (Leatherberry 1997). Remaining large tracts of southern forest are in areas that were not developed due to nutrient-poor conditions, public ownership, low commercial value, or relative inaccessibility (e.g. rough topography, susceptibility to flooding).

The ecology of the southern forests is also being affected by non-native species. Unlike the northern forests, the southern forests have been widely colonized by invasive plants. Non-native buckthorns (*Rhamnus* spp.), honeysuckles (*Lonicera* spp.), and garlic mustard (*Alliaria petiolata*), are especially troublesome on upland sites. Reed canary *grass (Phalaris arundinacea*) often invades bottomland forests after a disturbance like a windstorm or harvest, and limits tree regeneration. Other problematic invasive species of southern forests include Japanese barberry (*Berberis thunbergii*), multiflora rose (*Rosa multiflora*), Oriental bittersweet (*Celastrus orbiculatus*), and moneywort (*Lysimachia nummularia).* When abundant, invasive plants alter forest composition and structure, and can ultimately affect successional patterns and future forest conditions (WDNR 1997).

Faunal species composition and relative abundance in the southern forests have changed dramatically from historical times. The large herbivores such as American bison and elk, which were not abundant historically, are largely extirpated, as are their major predators the cougar and timber wolf. Black bear and bobcat are uncommon, and the timber wolf and fisher have only recently recolonized a small portion of the southern forests, primarily in the Central Sands region. The wild turkey, extirpated in the late 1800s, was reintroduced to the state in the mid-1970s by WDNR and various partners. The now-extinct

Passenger Pigeon would have had a great impact on the dynamics of the southern forest because of its sheer numbers and habits. Flocks of Passenger Pigeons consumed vast quantities of acorns and beechnuts, and may have been dispersal agents for those species (Schorger 1955).

Although there is a paucity of data, it is generally believed that white-tailed deer were relatively common during pre-EuroAmerican settlement times (perhaps 20-50 deer per square mile). White-tailed deer populations declined to very low numbers during the period after EuroAmerican settlement as a result of subsistence hunting and conversion of land to agriculture (Dahling and Guettinger 1956). Deer numbers remained low until the late 1960s, when populations began to increase. In prime habitats in southern Wisconsin, deer densities have reached 100 per square mile. Deer herd densities are significantly altering forest composition through herbivory, especially impacting the herbaceous layer, but also reducing regeneration success of some tree species (Wisconsin Conservation Congress 2001). Recently, white-tailed deer have begun using suburban areas and parks. Deer densities in these areas can be even higher than in rural areas, leading to extensive damage of landscaping plants as well as remnant native vegetation.

In addition to the serious impacts of herbivory by white-tailed deer, there are a number of other important factors that negatively impact native plant diversity in southern Wisconsin's forests. These include: permanent forest fragmentation; isolation of remnant forest patches; persistent livestock grazing; high-grading of large canopy trees and lack of subsequent regeneration; the continued spread of invasive non-native plant and animal species; and human use impacts such as trampling, vehicle use, disruption of hydrology, and residential development. These factors can alter the composition and structure of vegetative communities through competition, changed habitat conditions (light, humidity, soil moisture, soil structure, allelopathy), direct elimination of native species (by grazing, trampling, development, etc.), or by limiting the ability of plant seeds or pollinators to disperse between forest fragments. Changes in forest plant community structure and composition in turn can interfere with the habitat requirements of some wildlife species (Wisconsin Conservation Congress 2001).

The size and landscape context of a forested tract can also affect native plant species diversity. Some of the earlier studies that examined these issues reported that tree species composition and structure in southern Wisconsin was affected by shade-intolerant edge species in isolated forest fragments of up to about 20 acres, with edge effects penetrating farthest into drier sites (Guntenspergen 1983). On more mesic sites of up to 13 acres, the effective forest interior where shade-loving trees could thrive was significantly reduced. In formerly forested landscapes elsewhere in eastern North America that now consist of small isolated forest remnants surrounded by development or agriculture, substantial loss of interior habitat has been documented and is persistent. Tracts of roughly 250 acres exhibited negative edge effects such as reduced species richness, declines in cover of native understory plants, and increases in non-native species on 14% of the total area (Fraver 1994). Current forest plant research throughout Wisconsin has raised concerns that these effects are both more pervasive and more persistent than earlier work had shown. Apparent trends noted in southern Wisconsin forests include a significant increase in woody stem density of both native and nonnative species and an overall loss of species richness. The loss of species richness becomes especially dramatic when non-native species are removed from consideration. The presence and cover values of non-native plants have greatly increased, while rare, and even some formerly common native forest plants have shown the greatest declines. Once they have been lost from a site, many native forest herbs will likely remain excluded from areas they previously inhabited because of competition from recently established and spreading invasive species, difficulties in dispersing between isolated fragments, loss of pollinating insects, and continued browse pressure from large herbivores (Rooney *et al*. 2001, Waller *et al*. 2001, Wiegmann 2001, Rogers pers comm 2003).

Bird species of high conservation concern in southern Wisconsin's forests include the following regularly occurring species: Cerulean Warbler, Worm-eating Warbler, Kentucky Warbler, Prothonotary Warbler, Hooded Warbler, Canada Warbler, Acadian Flycatcher, Golden-winged Warbler, Blue-winged Warbler, Wood Thrush, and Red-headed Woodpecker. They were identified as species at risk by the Wisconsin Bird Conservation Initiative (WBCI), a coalition of over 120 Wisconsin groups interested in bird conservation. WBCI bases the risk assessment on a planning process developed by Partners in Flight (PIF) (Knutson *et al*. 2001). WBCI will be working through its endorsing partners in a variety of ways to implement the PIF plan in Wisconsin. The plan has outlined conservation opportunities for priority bird species with respect to habitat restoration, though for the Cerulean Warbler, due to its widely perceived rarity, more extensive levels of monitoring and additional guidelines for habitat restoration are being proposed or are under development. Specific habitat conservation issues identified included fragmented or otherwise altered forests, fire suppression and intensive agriculture that has eliminated oak savannas and prairies, and wetland loss.

Studies of bird habitat in southern Wisconsin's forests have identified increasing tract size as an important factor in bird diversity, and especially the abundance of long-distance migrant species (Ambuel and Temple 1983). Mossman and Hoffman (1989) summarized results of a number of studies of breeding birds, noting that isolated tracts of 40 or even 80 acres were

dominated by generalist species. These smaller forest patches are dominated by edge habitats, unsuitable for interior forest-dwelling species. A number of bird species were found primarily in tracts of 100 acres or larger, and several species such as Kentucky Warbler, Hooded Warbler, and Worm-eating Warbler were found to only breed consistently in tracts over 500 acres in size. Other rare or uncommon bird species that depend on large blocks of unfragmented forest for breeding habitat are also declining as patch size decreases or forest habitat is otherwise rendered unsuitable (Knutson *et al*. 2001). The Red-shouldered Hawk, Pileated Woodpecker, Acadian Flycatcher, Wood Thrush, Louisiana Waterthrush, Cerulean Warbler, and Black and White Warbler are among the other forest birds that do best in larger tracts of unbroken forest. Many birds and other species with more generalized habitat needs are now stable or increasing as populations of forest habitat specialists decline. A study in the Baraboo Hills found that closed-canopy forests, or those with gaps of a half-acre or smaller, were less likely to be impacted by the brown-headed cowbird, a significant nest parasite that reduces production of offspring for a variety of bird species. Here, cowbird nest parasitism rates were higher in proximity to forest edges (Brittingham and Temple 1983). Cowbird impacts appear to vary with landscape factors. In the Driftless Area, these included the amount of forest cover and the size and shape of forest patches, which influence occupancy by suitable host birds. Cowbirds also require feeding sites within three miles of breeding habitat. Landscapes with intermediate levels of fragmentation, such as those where forests cover 30-50% of the area, may offer cowbirds foraging areas as well as host availability (Gustafson *et al*. 2002). Nest predation by species like Blue Jays, Crows, raccoons, skunks, and free-roaming cats is also a major impact on bird reproduction.

Ecological concerns in the southern forest generally focus on the loss, dramatic decrease, or alteration of communities that are important because of their extent, geographic distribution, or rarity. Natural disturbance processes, especially fire, do not function in today's landscape as they did in the past. Land use has led to fragmentation and significant declines of some species. Approximately 56% (537) of the species listed as state or federally endangered, threatened, or special concern in the state, have been documented in southern Wisconsin (WDNR 2002). Of these, 38% (208) are plants. Among the rarer forest plants are the state-endangered bluestem goldenrod (*Solidago caesia*), and the state-threatened snow trillium *(Trillium nivale*) and forked aster (*Aster furcatus*). The others are mammals, birds, fish, reptiles, amphibians, insects, mussels, and invertebrates. There have been 9,288 documented occurrences of these rare species in the area south of the Tension Zone in Wisconsin; this is approximately 57% of the total rare species documented statewide (WDNR, BER 2002). Many rare plants and animals are dependent on distinctive microsites that occur within forest environments, such as seepages, ephemeral ponds, coarse woody debris, or rock outcroppings. The WDNR's Bureau of Endangered Resources has responsibility for state and federally listed species, as well as many non-game species, and is in the process of developing management guidelines for them.

Issues of Ecological Composition, Structure, and Function

The boundaries between composition, structure, and function of an ecosystem are not always sharply defined. A change in composition can lead to a change in structure and ultimately a change in function. Issues are described within a category where effects are most apparent, but indirect effects also occur in other categories.

Composition

- Some major tree species have decreased in abundance due to infection by diseases such as Dutch elm disease, oak wilt, and butternut canker. Species affected were formerly widespread, and provided important wildlife habitat and forest products; they include the elms, the "black" oaks, and butternut (*Juglans cinerea*). American elm was a dominant canopy species in bottomland forests; it had large stature and provided a long-lived structural feature with many nesting and foraging sites.
- Other forest species are declining, sometimes for reasons that are poorly understood. Tamarack has experienced substantial dieback in parts of its southern Wisconsin range. Its ability to persist, in at least some locations, is questionable. Oak forests are difficult to regenerate, and are being harvested at rates exceeding growth. Regeneration of bottomland forests has also become problematic. Research is needed to identify the greatest threats and propose means of addressing them.
- Invasive species can change forest composition. Non-native invasive plants are widespread and often dominate the understory of southern forests, reducing the abundance of, or eliminating, native plants. Some invasive plants inhibit regeneration of forest trees; examples include reed canary grass in bottomland forests, buckthorn in oak forests, and garlic mustard in relatively closed forests of many types. Some non-native tree species commonly planted in urban areas are becoming invasive and spreading into woodlands, where they compete with native trees. Invasive shrubs, vines, and herbs will likely continue to spread, limiting the reproduction of ecologically and economically important trees, and adversely impacting native plant communities. Forest diseases and insect infestations are a continual problem due to new introductions of non-native species, and changes in the invasiveness of existing pests. Infestations

of the gypsy moth, a non-native insect, may alter the future composition of southern forests, favoring those tree species that are less susceptible to attack or more resilient to defoliation. The native disease oak wilt is currently damaging various oak species. Asian longhorned beetle is a potential threat to maples and other hardwoods. Attempts to control diseases and other forest pests may have unforeseen secondary consequences.

- Poor management practices, such as high grading, continue to degrade forests by: diminishing the abundance of, or eliminating, important canopy species; producing shrubby growing conditions that allow ecologically and economically less desirable species to increase (e.g. red maple, cherries, ironwood); and restricting regeneration of tree species selectively removed, such as oaks and black walnut.
- Maintenance of glacial relict communities will remain a challenge due to management for other vegetation types, which may alter site context and conditions. Impacts of climate change might be especially deleterious for sensitive northern relicts in southern Wisconsin.
- Certain forest raptors and neotropical migratory songbirds have been identified as high priorities for conservation attention due to perceived rarity, threats, and/or declining populations (Knutson *et al*. 2001).

Structure

- Large forested patches and landscape connectivity are important for a variety of wildlife species. Fragmentation of forests through conversion to agricultural, residential, and urban uses has reduced their suitability for many animal species that were formerly widespread in the southern forests. Historic landscape patterns have been altered, reducing forest patch size and increasing patch isolation. Cowbird parasitism and nest predation are limiting factors for many bird populations in forest fragments. Population isolation is a serious consequence for those species with limited dispersal capabilities, or for plants with animal pollinators that cannot easily move between habitat patches. Development and forest conversion will undoubtedly continue for the foreseeable future.
- Logging practices, extreme weather events, and insect or disease outbreaks, can damage or eliminate supercanopy trees, large canopy trees, snags, and potential coarse woody debris that provide niches critical to the survival of many forest organisms.

Function

- Older-age classes of longer-lived species are generally lacking, resulting in a deficiency of certain niches for habitat specialists, and affecting ecological processes such as decomposition and nutrient cycling.
- High densities of white-tailed deer have damaged, and continue to impact, natural, agricultural, and urban vegetation. "Excessive and preferential browsing causes long term impacts by reducing growth on some species and changing natural species composition. Excessive browsing also leads to reduced regeneration success or even [local] extirpation of some plant species." (Wisconsin Conservation Congress 2001). In southern Wisconsin, regeneration of oaks is reduced by herbivory, while less palatable species such as black cherry, bitternut hickory, and ironwood are not impacted and thus gain a competitive advantage.
- Hydrologic disruptions such as dam construction, dredging, and ditching have altered the hydrologic regimes to which many lowland hardwood forest species are adapted.
- Lack of fire has altered historic successional patterns, resulting in the conversion of prairie and savanna to forest and shifting the composition and structure of forest types that formerly burned. Dense shrub and/or sapling understories have developed in many places, eliminating or reducing populations of plants that require open conditions. Shade-tolerant understory species have increased, especially in oak and pine forests. Some sites that are now forested with scrub oak and pines were historically sandy barrens habitats. Barrens vegetation continues to decline because of fire suppression, the continued encroachment of woody species, and conversion to pine plantations.
- Wildlife diseases have recently become large concerns in Wisconsin. The long-term effects of Chronic Wasting Disease in the white-tailed deer population are unknown at present. West Nile Virus has the potential to negatively affect populations of many wildlife species.
- Trampling by livestock contributes to the spread of non-native plant species, and can cause soil compaction and erosion.
- Pollution from acid deposition is not a severe problem in southern Wisconsin's forests. Elevated ground-level ozone concentrations, mostly produced by the combustion of fossil fuels, are causing foliar injury to ozone-sensitive plant species. Injury is most noticeable in counties along Lake Michigan, but injured foliage has been found throughout the state. The impact of this injury on plant communities is being studied, but the effects are difficult to assess because of interacting natural events and human factors. Pesticides have been shown to impact certain wildlife species, including some insects and amphibians, but effects on forest ecosystems as a whole are unclear.

- Extinct and extirpated animals that inhabited Wisconsin's southern forests included keystone species such as the Passenger Pigeon, cougar, and wolf. The wild turkey, extirpated from Wisconsin in 1881, was successfully reintroduced in the mid-1970s. The loss of keystone species has long-lasting effects on food webs.

Land Use and Environmental Considerations (see also: Socio-economic chapter)

- Conflicts may sharpen among timber production, preservation, restoration, recreation, and wildlife management concerns. Reforestation or afforestation of open landscapes can conflict with grassland or savanna restoration and management. Conversely, restoration of savanna and barrens habitats in forested landscapes can conflict with the maintenance or development of forest conditions. Diverse and often conflicting demands cannot always be addressed within a limited land and forest resource base.
- Periodic disturbances, such as prescribed fire or other forest management activities needed to maintain economically desirable species like oaks in the southern forest, are often expensive and sometimes controversial.
- Changes in the tax structure, or ordinances on parcel size, can be disincentives to maintaining Wisconsin's southern forests. The 'use value' method of assessing agricultural land has led to impacts on farm woodlots. One such impact is that cattle are increasingly allowed into woodlots to qualify them for the lower agricultural tax rate. Some locales have imposed minimum restrictions on parcel size in an effort to retain farmland, but may contribute to landowners breaking large holdings into many medium-sized tracts rather than splitting off a few small lots and retaining a larger block. Incentives and landowner awareness are often inadequate for the development, maintenance and restoration of large forested tracts.
- Forest habitats also continue to be directly lost to residential development. Parcelization is increasing for a variety of social and economic reasons, and contributes to residential development.
- As infrastructure (e.g. roads, rail lines, and utility corridors) is expanded or upgraded, forests are subject to increased fragmentation, isolation, and colonization by invasive species. The placement of these features can disrupt hydrology, resulting in sedimentation, alteration of flow patterns and drainage, and the drying of springs and small streams.
- As their availability decreases, demand for oak and other economically desirable species will likely continue to increase. Species substitution may occur, materials may be shipped in from other areas, or forest products companies may leave, resulting in economic loss to the region. Sustainable production of forest products is needed to support economies over the long term.

Southern Forest Community Ecological Opportunities

- Landscape and regional-level planning processes can be tools for resolving conflicting public demands related to land use and forest management.
- Landscape and regional-scale analyses can be used to identify scarce forest types and large forest patches, their conservation significance, and their ecological and social values. Protection and restoration can be incorporated into management plans.
- Landscape and regional-level assessments and planning can identify areas suitable and appropriate for forest, savanna, and grassland management. The process could include consideration of initial and current site conditions, historic vegetation and site potential, as well as landscape context, and would weigh the relative benefits of managing for different vegetative communities. TNC's Ecoregional Plans and the WDNR's Land Legacy report provide examples of a process for identifying land areas that have high suitability for particular uses.
- Large-scale forest preservation and management opportunities are relatively few in southern Wisconsin. The major river corridors, portions of the Central Sands, and areas with relatively complex topography (Driftless Area, Baraboo Hills, Kettle Moraine) contain the most extensive forests in southern Wisconsin and also offer the best opportunities to ensure that key environmental gradients are included in conservation efforts. There are opportunities to expand upon existing forested blocks in some locations, such as in the Kettle Moraine, the lower Wisconsin River area, and parts of the Central Sands. Reforestation provides an opportunity to reduce forest fragmentation and provide for corridors and landscape connections. However, many parts of southern Wisconsin have little potential for forest restoration due to established agricultural or urban uses.
- Potential exists to develop additional information and methods for southern forest restoration. Herbivory might be controlled through white-tailed deer herd reduction on a large scale. Locally valuable sites could be protected through the use of fences or repellents.
- Restoring or improving hydrologic regimes that have been altered by water control structures or land clearing could benefit floodplain forest communities as well as fisheries, aquatic life, and wetland-dependent wildlife.
- The use of prescribed fire can regenerate fire-dependent forest species and restore savanna-like structure, and sometimes reduce the impacts of invasive shrubs and vines.

- Restoration and maintenance of oak forests and associated communities, especially in large blocks, older age classes, and regenerating stages, would address the lack of representation of age classes and structural conditions in these forest types.
- Silvicultural techniques can be used to maintain or restore compositional and structural diversity in southern Wisconsin's forests, including increasing the component of snags and large woody debris to improve habitat for specialists needing these structural features. The context of surrounding forest's successional stages, patch size, and connectivity, as well as regional scarcity and trends of different forest types, are considerations when developing site-level plans.
- There are opportunities to work with urban planners and land managers to foster the restoration of native forests and other native plant communities in urban parks and residential landscaping.
- Disease-resistant American elm varieties exist that could be planted to replace the lost trees, although there is concern about local genotypes. Butternut trees that appear to be surviving the canker could be conserved for development of future resistant strains. Opportunities abound for research on forest diseases and invasive species.
- Invasive plant species' impacts on native communities can be reduced through a variety of management techniques, including prevention, eradication, or control by mechanical, biological and chemical means.
- Economic incentives could be developed and used to protect those species and natural communities of greatest conservation concern.
- Management guidelines are being developed for the most sensitive southern forest species, and can be utilized in community and landscape management to ensure that populations of these species are maintained or enhanced.
- Opportunities to provide public information and education about the economic and ecological values of native southern forest ecosystems are increasing, but more effort will be required to develop and disseminate information about complex ecological issues.

Forested areas of conservation concern

These are key areas of forest in southern Wisconsin that are of conservation concern due to scale, scarcity of embedded natural community types, importance as connectors, quality/integrity, or a relatively unfragmented condition compared to surrounding landscape.

- Baraboo Hills, including Devil's Lake State Park (upland types, including conifer "relicts")
- Kettle Moraine (dry types in the south, more mesic communities in the north)
- Kickapoo River Valley (upland types, including both mesic and dry conifer "relicts")
- Driftless Area forests (relatively high percentage of forest cover, including northern "relicts", steep environmental gradients lead to variety of communities)
- Central Sands (pine-oak forests, conifer swamps of tamarack-black spruce)
- Lower Wisconsin River (lowland hardwood forest, upland bluff forest)
- Lower Chippewa River (lowland hardwood forest, upland bluff forest)
- Lower Black River (lowland hardwood forest, upland bluff forest)
- Mississippi River Bottomlands (lowland hardwood forest, upland bluff forest)
- Yellow River Bottoms (lowland hardwood forest)
- Lower Lemonweir River (lowland hardwood forest)
- Cedarburg Bog (white cedar swamp, ash swamp, upland hardwood forest)
- Milwaukee River Corridor (lowland hardwood forest, upland hardwood forest)
- Additional sources for specific information can be found in The Nature Conservancy's Prairie Forest Border Plan, DNR Land Legacy sites, and State Natural Area proposals.
- Any forest remnant exceeding 240 acres – a rough threshold for some forest interior birds (Mossman and Hoffman 1989).
- Smaller stands, if they represent rare types or successional stages, occur in strategic locations (e.g., along the Lake Michigan shoreline) and merit conservation attention despite their size.

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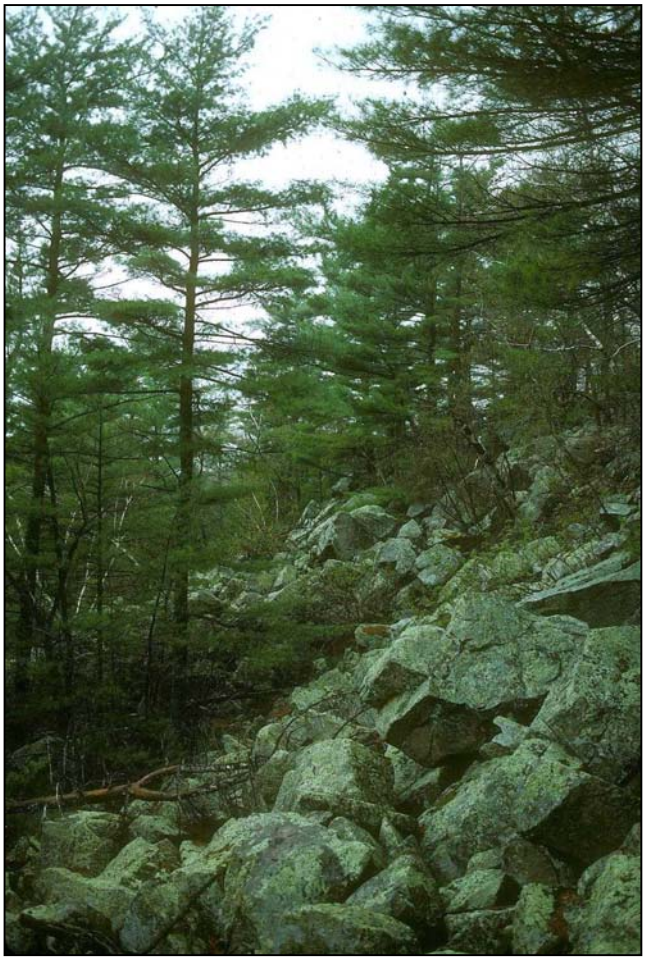
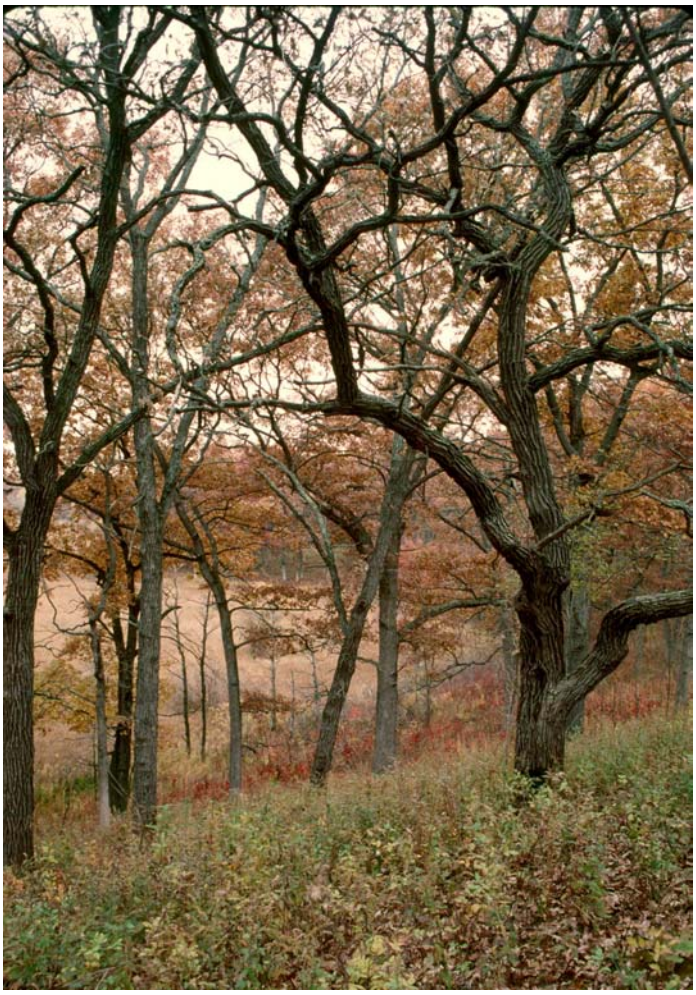
Floodplains in the Southern Forest area formerly supported extensive swamp hardwood forests of American elm, silver maple, green ash, cottonwood, and swamp white oak. Most of the fertile floodplains were converted to agricultural land uses, as in this area along the Baraboo River east of the town of Baraboo. Note the former river oxbow, visible as the small crescent-shaped pond in the center of the photograph. The oxbow was formerly embedded within forest, providing breeding and feeding habitat for many organisms. *Photo by Lou Maher.*



White pine is a component of southern forests at scattered locations on a variety of site types. This site is a sandstone bluff and talus slope in northeast Grant County. These conifer "relicts" often support plants and animals that are more typical of communities occurring in northern Wisconsin. They may also support species that are highly specialized and often rare, having adapted to site features such as bare rock, cold air drainage, or groundwater seepage. *Photo by Eric Epstein.*

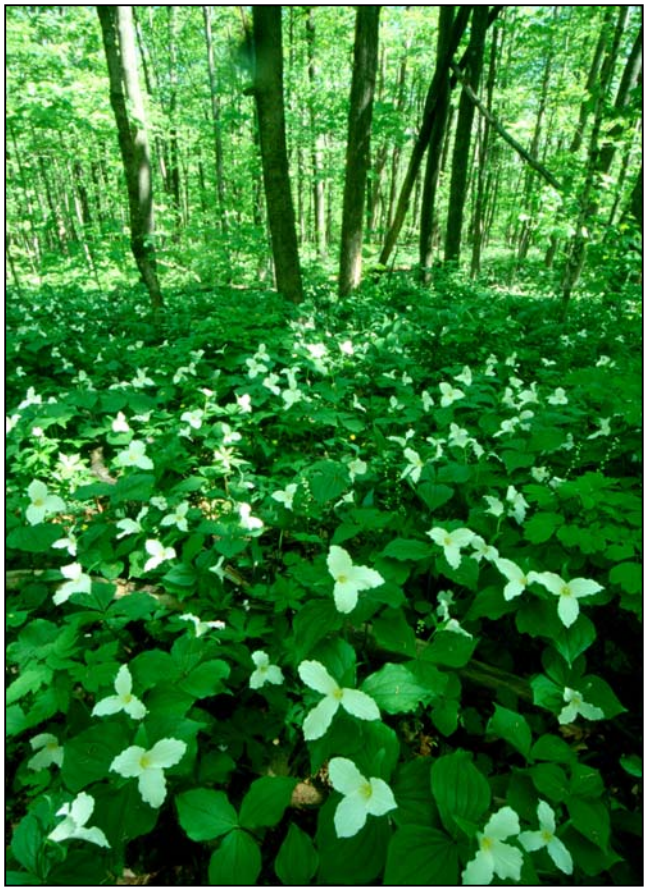


Oak savannas and oak woodlands historically developed where repeated ground fires of high frequency but relatively low intensity suppressed competing vegetation. The bur oaks shown here have a spreading, twisted, branch architecture. The stand also contains white and red oaks, and shagbark hickory. Open understories, lacking shrubs or saplings, occur where fires or grazing have set back the growth of woody species. Periodic fire can favor the development of a diverse groundlayer dominated by native herbs. Grazing can maintain similar tree structure, but the understory often becomes dominated by non-native herbs and spiny or thorny shrubs. *Photo is from Lulu Lake in Walworth County, by Thomas Meyer*

Oak-dominated forests are the most common type of forest found in southern Wisconsin. This example is free of the invasive buckthorns, honeysuckle, and other shrubs that often impair forest regeneration. Oak regeneration is also inhibited by herbivory, and competition from other native tree species that were historically suppressed by fires. *Photo by Eric Epstein.*

'High-grading', a logging practice where all the valuable trees are removed, is relatively common in southwest Wisconsin's oak forests. The remaining poor-quality trees often inhibit regrowth of desirable species, so that the forest is incapable of producing an economic return for decades following. Landowners are encouraged to utilize the services of a forester when planning and conducting timber sales so that this situation does not occur. Recently, processes have emerged for certification of sustainable forest practices. Certification holds promise as a way to discourage poor forest management. *Photo by Eunice Padley*.

Allowing cattle to roam in woodlots leads to loss of ground vegetation, soil erosion and compaction, and eventual decline of the trees. Grazing can increase the abundance of thorny or spiny shrubs, and encourage the invasion of non-native plants and weedy native species. Most southern Wisconsin woodlands have been subject to grazing at one time or another since EuroAmerican settlement. Depending on the intensity and duration of cattle impacts, vegetation may recover over time. *Photo by Eunice Padley.*



Trilliums and spring ephemerals are part of the flora in northern hardwood and central hardwood forests of southern Wisconsin. They can be abundant where cattle have been purposefully kept from the site. *Photo is from Powers Bluff, by Thomas Meyer.*

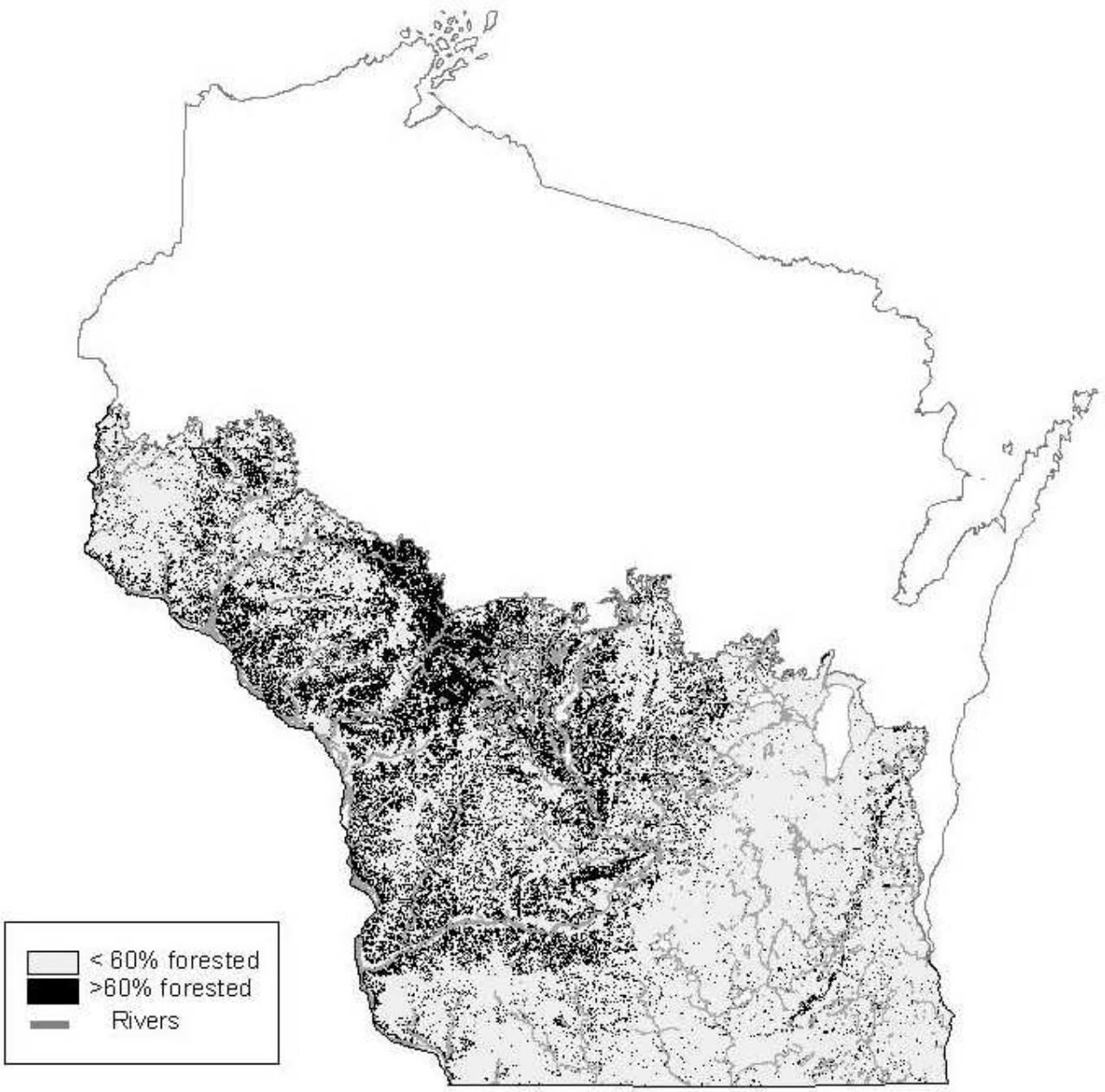
'Red pine pocket decline' is a disease complex involving several species of root and lower stem-feeding beetles along with their fungal symbionts. These insects initiate a sequence of events that create mortality in red pine plantations. They introduce a fungus, which spreads through the extensively grafted root system and stresses the trees it invades. These otherwise healthy pines then become attractive to beetle attack, creating an expanding border of dead trees. Unless root grafts are severed, removing the diseased trees will not halt the spread of the fungus to healthy trees. *Photo in Sauk County, by Mark Guthmiller*

Most of southeast Wisconsin's ecosystems developed on a large glacial till plain. This location north of Madison shows the gently rolling topography typical of till plains. The area was formerly a mix of oak forest, savanna, and prairie, but most has been converted to agriculture. Woodloots are often found in parts of the landscape that are steep, rocky, or wet - conditions that are less favorable for agriculture. *Photo by Eunice Padley*

Development in woodlands is occurring rampantly around urban areas in southern Wisconsin. The loss of larger blocks of forested habitat can make the area less suitable for some wildlife species and more suitable for others. Common species that can survive in a variety of habitats, or "generalists", tend to increase while habitat "specialists" that are more reliant on a unique habitat or a larger block of forest are more likely to decrease. Generalists often found in southern Wisconsin include raccoons, skunks, crows, grackles, and robins. *Photo by Eunice Padley.*

The Baraboo Hills, shown here facing north over Devil's Lake State Park, represent one of the few large forested blocks in southern Wisconsin. Along with forests in or near the lower Wisconsin River, it makes up the majority of large contiguous forests in this part of the state. Agricultural uses are dominant in the level portions of the landscape. Fields often abut the forests as a sharp edge rather than the gradual ecotone that would have existed in the pre-EuroAmerican settlement era. *Photo by Lou Maher.*

Forested lands in Southern Wisconsin



This map shows areas of southern Wisconsin that are predominantly forested. It highlights the importance of forests in the Western Coulees and Ridges and Central Sand Plains Ecological Landscapes, as well as the Kettle Moraine forests in the southeastern part of the state. This map was made using WISCLAND Land Cover data that were aggregated to 18 acre blocks. Blocks were shaded when more than 60% of the original data cells they included were identified as forested. To locate Ecological Landscape boundaries or other features, overlay this map with transparencies found in the Statewide Overlays section.